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# Minerals Environmental In-House and Contract Research and Development in Fiscal Year 1980

By Staff, Division of Minerals
Environmental Technology

UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES
Lindsay D. Norman, Acting Director

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# MINERALS ENVIRONMENTAL IN-HOUSE AND CONTRACT RESEARCH AND DEVELOPMENT IN FISCAL YEAR 1980

by

Staff, Division of Mineral s Environmental Technology


## ABSTRACT

This publication summarizes the in-house and contract research and development projects programed for fiscal year 1980 by the Bureau of Mines under its Minerals Environmental Research activity. The document provides a mechanism for interested parties, including potential contractors, to gain insight into ongoing and projected work of the Bureau's environmental research efforts.

Research to identify and correct environmental problems associated with mining and metallurgical operations has long been an integral part of the Bureau's mission. Through the years, efforts of various Bureau programs have yielded valuable information on the origin and control of many of these problems. With the reorganization of the Bureau of Mines in 1979, the Minerals Environmental Technology program was structured to consolidate these efforts into a single program that will systematically investigate all aspects of mining- and processing-related environmental pollution and damage--from initial discovery of the mineral resource to ultimate return of the land to productive use. In fiscal year 1980, the Bureau received an appropriation of about $21 million to conduct research and development work on these problems.


## INTRODUCTION

This summary document is intended to provide a means for interested parties to obtain general information about the Bureau's environmental research programs, and also is meant to serve as a decisionmaking aid for R&D firms contemplating participation in the contract program.

Contracting in the Bureau of Mines is conducted in strict accordance with Federal Procurement Regulations, and solicitation is conducted by formal advertisement in the Commerce Business Daily. No additional information will be supplied on new contract projects until after the requests for proposal (RFP's) are made available and then only in strict accordance with regulations. This document is not intended to solicit proposals; all unsolicited proposals whose contents reflect the objectives of proposed projects listed herein will be returned without formal review.

## PROGRAM OUTLINE

The long-range goal of the Minerals Environmental Technology program is to reduce and ultimately eliminate the adverse environmental effects associated with mining and mineral-processing activities. The program's major objectives are--

1. To develop data and perform analyses necessary to predict and assess the environmental impact of mining and mineral-processing activities.

2. To provide improved technology that can be integrated into mining and process unit operations to prevent or limit the production of substances and conditions harmful to the environment.

3. To develop techniques and methodology to resolve environmental problems arising from past mining and processing practices and provide the assessments and technology necessary to assure optimal land utilization following extraction and processing operations.

The program is conducted by means of balanced in-house and contract efforts. The in-house effort develops technology through projects that are more efficiently conducted internally and maintains the necessary Bureau expertise to develop, monitor, and guide the contract research to assure the most efficient overall effort.

At the time of preparation of this document (early in fiscal year 1980), the research and development responsibilities of the program were performed under two broad subprograms, Environmental Assessment and Control Technology. The material in this document is presented in this fashion, in compliance with the budget structure initially proposed for fiscal year 1981. Subsequently, the program was reorganized into four research and development subprograms, and the fiscal year 1981 budget submission was restructured accordingly. The program is currently managed along these lines. A fifth subprogram, Mined Land Demonstrations, is an applied technology component and is beyond the scope of this paper.

## ENVIRONMENTAL ASSESSMENT

### Subprogram Goals

This subprogram's overall goal is to develop an engineering and economically sound environmental data base and to perform necessary analyses of that data in order to provide the information required for informed, well-considered judgments and decisions by industry, government, and the public concerning mineral-related matters impacting the environment. Specific goals of this subprogram are--

1. To conduct environmental assessments to identify and measure present and future environmental hazards in the minerals industry.

2. To provide regulatory agencies with necessary environmental baseline information and analyses to assure that environmental standards promulgated are technically sound and cost effective.

## In-House Projects

1. Research Information Management System

Objective: To provide the Directorate, Minerals Research, and other groups with reports containing useful and timely information relevant to the research program. A computerized data base consisting of accurate current and historical information on all minerals research contract and in-house programs is maintained. This is an ongoing project.

2. Program Planning--Oil Shale

Objective: To provide technical assistance to Washington Office and Research Centers in program planning, review, evaluation, and coordination on the environmental aspects of oil shale mining and retorting. This is an ongoing project.

3. Stress Research Applied to Mine Design

Objective: To provide the necessary stress information required for mine design and subsidence prediction in oil shale. Specific tasks will include the determination of the in situ stress field at available sites in the central portion of the Piceance Basin, Colo. This work will be done at the Bureau's bored shaft along with the proposed rock mechanics research program. Studies of stresses, stress conditions, and stress transfer for various types of mining systems and mine structures will also be conducted. These studies would include the continuation of the mine design and stability program at the modified in situ experiment at Logan Wash, Colo. Finally, in a continuing effort to improve technology and because of problems with present instrumentation for measuring stress changes, an RFP may be issued to develop more accurate and reliable stress-change-monitoring equipment or to make the necessary improvements in the present instrumentation. This is an ongoing project.

4. Laboratory Determination of Static Parameters of Rock and Their Application to Mine Design and Subsidence Control

Objective: To develop static design parameters for oil shale and other mine rock materials, fractured and unfractured, under simulated field conditions or models made from the prototype rock. The proposed work includes--

a. Continuation of studies at Occidental Oil Shale Corp.'s Logan Wash project as the firm continues to study and add underground retorts.

b. Initiation of rock mechanics studies into experimental rooms cut into several projected mining horizons off of the Bureau of Mines bored shaft.

c. Initiation of rock mechanics studies from the first Occidental Oil Shale Corp. shaft on C-b tract.

d. Initiation of rock mechanics studies of cores from the Anvil Points Naval Reserve Oil Shale Project.

This is an ongoing project.

5. Geological-Hydrological Studies at the Oil Shale Mining Environmental Research Facility (Horse Draw, Piceance Basin, Colo.)

Objective: To obtain a detailed, three-dimensional geologic picture of the research facility site from the surface through the lowest research horizon and the occurrence of methane gas in the strata. Natural gas emissions will be monitored over extended time periods from drill holes in various zones. Geologic activities will consist of surface mapping, underground core drilling, and underground mapping. This is a new project.

6. Management and Liaison Services for Oil Shale Mining Environmental Research Facility

Objective: To provide management and liaison services at the research facility site. General duties will include the responsibility for assuring that the proposed research program is followed as outlined, that all applicable health and safety rules and regulations are followed. This is a new project.

7. Criteria for Evaluation of Environmental Effects of Surface and Underground Mining

Objective: To develop, through the use of geologic study techniques, criteria for predicting the environmental effects of surface and underground mining, and to assess these criteria for predictive use. This work includes the following specific goals:

a. To develop and/or expand cooperative agreements with coal mining companies who will be opening new surface or underground mines.

b. To utilize geologic study techniques to extend and complete a data base already on hand for selected areas of new mine development.

c. To select critical areas where small changes will have large immediate effects.

d. To monitor the development of new mines and the occurrence of environmental problems.

e. To correlate the development of environmental problems with recognized geologic or hydrologic conditions evident in the data base.

This is an ongoing project.

8. Systems Approach To Minimize Environmental Problems Associated With Major Mining Districts

Objective: To identify and evaluate the environmental problems, constraints, and causes common to major mining districts. The systems approach will allow the simultaneous evaluation of the interaction of a number of variables, such as environmental impact, economics, and mining method, to be conducted as the input parameters are varied. Short- and long-term plans will be devised to identify, develop, test, and demonstrate methods to ameliorate environmental problems without disruption of the mining or processing sequence. This is an ongoing project.

9. Oil Shale Data Bank Technology Transfer

Objective: To provide up-to-date data bank listings on oil shale bibliographies, patents, and research projects. New articles will be abstracted, keyworded, and entered into computerized search and retrieval files. Search services will be provided for inquiries to the oil shale data bank in the subject areas of premining, mine design and development, health and safety, retorting, mining equipment, and environment. Reports on the status of the data bank will be published, and technology transfer with other agencies and industry will be continued. This is an ongoing project.

10. Environmental Assessment of Peat Harvesting and Dewatering Systems

Objective: To develop and analyze environmental impact data concerning the single-pass peat-harvesting techniques, European harvesting and dewatering systems, and land reclamation techniques and results. An environmental assessment report will be prepared and used as a basis for determining environmental impacts regarding harvesting, dewatering, and reclamation for peat development. This is an ongoing project.

11. Impact of Mining on Soils

Objective: To identify and critique factors pertinent to soil distribution and classification schemes for those lands overlying mineral deposits. Existing land use evaluation techniques will be employed for those deposits of significant aerial extent to determine how much each factor adds or detracts from the value of soil as a mineral resource, in comparison with the value of underlying mineral deposits. Consideration will be given to the review and evaluation of geologic (premining) factors of soil that contribute to its baseline characteristics, such as vertical (compaction) and horizontal (erosion) movements, and of environmental changes resulting from mining and reclamation activities. Results will be assessed to learn the nature and extent of such changes and, in turn, to make recommendations for minimizing the effects of such changes or for enhancing desirable changes. This is a new project.

12. Analysis of Compliance Alternatives for the Surface Mining Act

Objective: To provide a starting point for the development of regulation compliance alternatives. Work will include a determination and inventory of Federal and State laws and regulations regarding permits to mine coal. Particular attention will be paid to the requirements of OSM in regard to surface mining and aspects of underground mining such as subsidence control and return of waste to abandoned underground workings. The high-cost tasks that must be performed to comply with the regulations will be identified. Where possible, critical path method (CPM) diagrams will be prepared to streamline the overall permitting process and reduce costs but still maintain the process integrity. From the compilation of high-cost tasks, research to reduce the overall cost of compliance will be recommended. This is a new project.

13. Environmental Monitoring of a Demonstration of Area Mining Using Conveyors and Draglines

Objective: To monitor the effects of using portable belt conveyors to assist draglines. Such a system may reduce reclamation requirements in areas currently mined by extended bench dragline operations. Due to concurrent backfilling operations in the system, erosion should also be reduced. Work in fiscal 1980 will consist of baseline data gathering and development of cooperative agreements with the U.S. Department of Energy and a coal company. This is a new project.

14. Assessment of Mine Water Drainage Problems

Objective: To assess and evaluate sludge disposal from acid mine water treatment plants in western Pennsylvania and northern West Virginia. The contribution of improper sludge disposal to environmental pollution will be examined. Also, the extent to which saline waters are encountered in the underground mining of coal will be verified as well as the severity of the resulting environmental problems and methods used or proposed for control. This is a new project.

15. Fugitive Dust Characterization and Quantification Related to Mining and Mineral-Processing Operations

Objective: To study the environmental effects of fugitive dusts created by mining and milling operations. The extent of hazard attributable to fugitive dust will be determined, methods of dust measurement and assessment evaluated, and control measures evaluated. This is a new project.

16. Trace Analysis and Molecular-Species Identification of Accessory Elements

Objective: To improve the analytical capabilities for identifying and analyzing accessory elements in metallurgical process streams. Devise and assemble analytical apparatus that will simulate new mineral processing systems being investigated by the Bureau. Choose one or more of the more promising new metallurgical processes and identify accessory mineral molecular species and equilibrium products associated with discharge streams. This is an ongoing project.

17. Particulate Mineralogy Unit

Objective: To assist governmental agencies by identifying and taking quantitative measurements of mineral particulates derived from mining and mineral-processing operations, and support mineral and metallurgy research activities by making analytical measurements. Mineralogical identifications and measurements will be provided to in-house and contract Bureau research efforts as required. This is an ongoing project.

18. Improved Characterization of Accessory Minerals

Objective: To characterize metallurgical processing feed and waste materials and establish the nature and occurrence of accessory minerals, compounds, or elements that may be harmful to the environment. Studies to determine the distribution and chemical form of radioactive elements and fluorine in the process streams of major unit operations used to recover phosphate from Florida deposits will be continued. Support technology for the utilization of environmentally acceptable disposal of waste products from the citrate process demonstration plant at Monaca, Pa., will be provided. This is an ongoing project.

19. Tailing Pond Research and Testing Facility

Objective: To develop, test, and demonstrate promising designs, techniques, and materials of construction for mineral-processing tailings and evaporation ponds. Selected wastes associated with metallurgical processes being studied at other Bureau research centers will be obtained and tested for undesirable environmental effects such as leaching by simulated rainfall in small test ponds. This is an ongoing project.

20. Physical Chemistry of Metallurgical Process Engineering

Objective: To apply the principles of physical chemistry to analyze the distribution and disposition of accessory elements and compounds likely to cause subsequent environmental pollution problems from metallurgical processing operations. Distribution of accessory elements will be determined at each stage of the extraction processes for Pb, Zn, Cu, U, and Au-Ag using thermodynamic and kinetic data. Physical and chemical experiments will be conducted as required to generate thermodynamic and kinetic data lacking in the literature. This is an ongoing project.

21. Recovery of Accessory Minerals in Hydrometallurgical Processes

Objective: To determine the distribution and enhance the recovery of accessory constituents of ores to avoid the loss of these constituents when hydrometallurgical processing wastes are discarded. Collection of samples and characterization of accessory elements will continue in selected operating hydrometallurgical process streams and from potentially viable emerging processes. This is an ongoing project.

22. Accessory Minerals and Lithium From Clays

Objective: To devise methods for recovering lithium from domestic raw materials. Laboratory processing research will be completed for recovery of lithium from hectorite clays, other lithium-enriched montmorillonites, and lithium-bearing brines. Technology for recovery accessory minerals as byproducts from lithium resources will be evaluated. This is an ongoing project.

23. Environmental Control of Flotation Reagents

Objective: To minimize environmental degradation caused by flotation and solvent extraction reagents that are discharged in tailings from mineral-processing systems, and to develop methods for concentrating and analyzing chemical reagents that escape from sulfide and nonsulfide mineral-processing circuits. This is an ongoing project.

24. Characterization of Accessory Minerals in Hematitic and Ferruginous-Bauxite Deposits

Objective: To increase domestic mineral reserves and decrease the harmful environmental impact of metallurgical process feed materials by characterizing the physical occurrence of accessory minerals. To coordinate research to establish the mode of phosphorus occurrence in the hematitic minerals of Alabama and iron in low-grade ferruginous-bauxitic deposits in Alabama. The research efforts will focus on utilizing such techniques as optical microscopy, electron probe analysis, and X-ray diffraction to establish the mode of occurrence of gangue minerals especially those which may constitute health and/or environmental hazards. This is an ongoing project.

25. Removal of Particulates From Mineral-Processing Water

Objective: To devise methods for using oppositely charged solids as contact filters to remove low concentrations of undesirable suspended particulates from mineral-processing streams. Research will be completed on the contact filtration of asbestos from water using magnesium oxide, and present studies will continue on filtering methods and conditions to determine optimum stream flow rate, filter particle size, capacity, etc., for bed filters as well as blanket filters. Investigations aimed at replacing magnesium oxide with lower cost materials to remove asbestos from water will be conducted. This is an ongoing project.

## Contract Projects

1. The Impact of Surface Lignite Mining on Surface- and Ground-Water Quality in Texas

Objective: To determine the impact of surface mining Gulf Coast lignites on the surface- and ground-water systems. The work will concentrate on the conditions in Texas; however, it will have application to other Eocene Gulf lignite deposits in Louisiana, Arkansas, Mississippi, and Alabama. The primary objective will be met through a coordinated research program which will include the following four topic subobjectives: (1) Infiltration characteristics, (2) water quality, (3) hydrogeologic analyses, and (4) mine geology. This is an ongoing effort by Texas A&M University.

2. Evaluation of the Fire and Explosion Hazards of Oil Shale Mining and Processing

Objective: To collect sufficient data in existing large-scale mining projects, so that the dust, vapor, and gas hazards can be evaluated. This contract has been modified to include work on existing large mining projects. Modification will be funded under the Health and Safety program. This information will provide a basis for promulgating safety regulations and for monitoring compliance with possible regulations. This is an ongoing contract by TOSCO Research, Inc.

3. Outcrop Barrier Design for Appalachian Coal Mines

Objective: To provide design criteria for use in planning and designing outcrop barriers that will minimize barrier failures and mine drainage problems. Research will involve the design of outcrop barrier widths, potential problems associated with impounding large volumes of water in an abandoned bituminous coal mine, outcrop grouting, and measures necessary to prevent seepage through a coal barrier. This is an ongoing contract by Dames and Moore.

4. Environmental Factors Related to Surface Mining of Steeply Pitching Coal Seams

Objective: To analyze the environmental, operational, and reclamation problems in terms of the resource potential associated with surface mining steeply pitching seams. This is an ongoing contract by Ketron, Inc.

5. Inventory of Waste Embankments at Active Surface and Underground Metal/Nonmetal Mines

Objective: To compile the subject inventory to form a basis for developing research and future requirements in waste disposal techniques and management. This is an ongoing contract by Mountain States Research and Development.

6. Undercut and Fill System for Pitching Coal

Objective: To assess the technical and environmental practicality and economic feasibility of developing an undercut-and-fill mining system for steeply pitching (50° dip or more) coal seams. The undercut mining system will consider several research developments. These include pressure filling with a buried pipe discharge under sufficient line pressure to maintain flow by "hydraulic lift;" the utilization of cement foamers to create a cellular sand-cement mortar with better structural properties and reduced slurry viscosity; and the installation of preformed, wire mesh panels to increase strength of roof panels. This is an ongoing contract by Foster-Miller Associates, Inc.

7. Technical and Economic Feasibility of Using Cemented Backfill To Prevent Subsidence

Objective: To evaluate the technical and economic feasibility of disposing of coal-related waste (preparation plant waste, ash, and scrubber sludge) underground, by using it as backfill to abate subsidence. The resulting fill must have a compressive strength of at least 50 psi. Health and Safety hazards and the effect of Federal environmental regulations will be considered. Mining methods to be considered will be longwall, shortwall, room-and-pillar with partial extraction, and room-and-pillar mining whereby the pillars are extracted with bidirectional augers. This is an ongoing contract by Michael Baker, Jr., Inc.

8. Site-Specific Investigation of Environmental Problems Associated With Surface Mining of Heavy Oil Sands and Tar Sands

Objective: To design systems for surface mining, oil separation, and waste disposal, and to quantify the environmental problems which must be overcome for a specific oil sand or tar sand deposit. The scope of work includes a resource survey, site and mining method selection, and environmental analysis of selected concepts. This is an ongoing contract by Golder Associates, Inc.

9. Borehole Mining: An Environmentally Compatable Method for Mining Oil Sands

Objective: To demonstrate that oil sands can be mined economically and in an environmentally compatible manner with a hydraulic borehole mining system. Borehole mining has the potential of offering a method for extracting oil sands with minimal disturbance to environmental quality because no overburden is removed, no waste rock piles are required, tailings can be backfilled into the borehole cavity, ground water quality is undisturbed, no surface streams are polluted because a closed-loop water system is employed, and surface subsidence can be avoided by backfilling the mine cavities. This is an ongoing contract by Flow Industries, Inc.

10. Oil Shale Creep Testing at Elevated Temperatures

Objective: To develop a test program and conduct laboratory tests to determine the creep characteristics of oil shale at elevated temperatures. Results will be correlated with data and information developed under contract with the Colorado School of Mines to provide improved pillar design and subsidence prediction for commercial in situ retorting of oil shale. This is an ongoing contract by Terra Tek, Inc.

11. Evaluation of Best Management Practice for Mining Solid Waste Storage, Disposal, and Treatment

Objective: To extensively monitor ground and surface water and air quality at approximately eight waste disposal sites including metallic ores, phosphates, and uranium. To comply with sections 3004 and 4004 of the Resource

Conservation and Recovery Act, EPA is sponsoring this study with Bureau of Mines cooperation. EPA will use the results of this study in developing standards for "Best Management Practice" for disposal of metallic ores, phosphate, and uranium wastes. This is an ongoing contract by Interagency Agreement with EPA, and contract to PEDCO.

12. Geologic and Hydrologic Information of the Oil Shale Deposits of Piceance Creek Basin. Installing and Monitoring a Water-Measuring Station

Objective: To monitor the surface water runoff in Horse Draw, Piceance Creek Basin, Colo., for the purpose of determining the degradation in water quality, if any, attributable to the Mining Environmental Research Facility activities. This is an ongoing contract by U.S. Geological Survey.

13. Ground Water Resources in Relation to Surface Mining Coal

Objective: To assess impacts of surface mining on ground water and place these impacts in context with other types of disturbances to ground water resources, and to evaluate the state of the art of science and technology for minimizing the impacts of mining. The study will assess the need for various programs of research and training to assist in copying with problems of surface coal mining and its impact on ground water resources. This is an ongoing contract by National Academy of Science.

14. Monitoring and Modeling of Shallow Ground Water in the Powder River Basin, Mont.

Objective: To assess and predict the impacts that surface coal mining will have on the regional shallow ground water systems in the basin. Preliminary results indicate that the regional impacts of surface mining on water resources can best be studied by developing a more detailed subregional model. The present computer model of shallow ground water covers the entire structural Powder River Basin and uses finite-difference nodes of 38.6 square miles. At this scale, significant impacts are confined to a few nodes in the model. It has become apparent that subregional model of the hydrology in a mining area within the basin would be a valuable tool for studying the probable cumulative impact of surface mining. This is an ongoing contract by Hittman Associates, Inc.

15. Preparation of an Environmental Impact Statement for the Bureau of Mines Oil Shale Research Tract

This modification depends on results of analysis of Multi Minerals Corp.'s processing program. This program proposes to burn rock/shale in the retort. Preliminary reviews and meetings indicate the need for an EIS, which the contractor is preparing according to the NEPA process. This is an ongoing contract by VTN Colorado, Inc.

16. Comprehensive Environmental Evaluation of Mining Deep Deposits of Oil Shale

Objective: To identify and prioritize the types and magnitudes of environmental and health and safety impacts associated with the extraction of deep oil shale and the disposal of mine waste. This is a new project.

17. Water Management Aspects of Oil Shale Extraction and Retorting in the Uinta Basin, Utah

Objective: To devise the most environmentally acceptable methods of water management for shale oil industries in the Uinta Basin, Utah. The study will also include the technical and economic factors to be considered in the water management methods proposed. This is a new project.

18. Effects of Coal Mining on Ground Water Resources in Northern Appalachia

Objective: To determine the effect of underground coal mining on the quality of ground water in the Northern Appalachian coalfield. Work will include the study of ground water depletion related to underground coal mines in Northern Appalachia; the study of water quality changes related to underground coal mining; and the study of the geohydrologic settings of areas affected or unaffected in an attempt to develop a better understanding of ground water pollution and suggest practical controls. This is a new project.

19. State-of-the-Art Assessment of Onshore Disposal of Manganese Nodule Rejects and Identification of Environmental Considerations

Objective: To identify and describe alternative methods of onshore disposal of manganese-nodule-processing wastes. Contractors will review waste disposal techniques and determine the applicability of these techniques to onshore disposal of ocean mining wastes. Emphasis in the evaluation shall be on potential environmental, operating, and cost considerations. Relevant Federal and State laws shall also be considered. This study will provide baseline data which can be integrated with the data from this nodule waste material properties project to predict the best disposal methods. This is a new project.

20. Premine Waste Disposal Planning

Objective: To develop a manual for a systematic preparation and evaluation of milling waste disposal plans for metal and nonmetal mines. The selections of a plan will depend on the environmental, technical, economic, and regulatory constraints placed on the operation. The contractor shall develop a step-by-step procedure for evaluating a rational disposal plan with these constraints. This is a new project.

21. Mine Waste Location by Satellite Imagery

Objective: To investigate the potential for using satellite (LANDSAT) data for detecting coal and metal-nonmetal waste and tailings disposal sites. The contractor will determine if the band-ratio method of preprocessing of the LANDSAT multispectral data before classification can be used to detect and identify waste embankments. This could provide a rapid and accurate means of updating surface and underground mining wastes and tailings disposal sites data. State and Federal agencies, and mining companies could use the data for environmental assessments and planning. This is a new project.

22. Environmental Monitoring Instrumentation in Mining

Objective: To identify the full spectrum of environmental monitoring instrumentation in order to establish the monitoring options and potential capability in the mining industry. The 1977 Surface Mining Act and resulting regulatory requirements will be used to identify specific monitoring goals. Manufacturers of monitoring instrumentation will be requested to identify specific instruments and their capabilities and limitations. A report will be assembled listing the monitoring requirements and the instrumentation available to do the monitoring. The report will include a discussion of the relative match between the state of the art in instrumentation and the requirements of the regulations. This is a new project.

23. Impact of Mining on Ground Water in the Southwest Copper Mining District

Objective: To assess the effects of mining on the ground water quality, quantity, movement, and availability in the Southwest copper mining district. A determination will be made of the impact due to various mining techniques and practices. The results will be used to determine the seriousness of the problems and the necessary corrective actions. Results from the study will lead directly into Bureau R&D for remedy of unacceptable environmental impacts. This is a new project.

24. Testing and Evaluating the Characteristics of Northern Minnesota Peat

Objective: To determine the proper mix ratio of clay to subsoil peat, and supplemental nutriment requirements to reclaim mined peat land into productive agricultural and/or forest land. Based on the test information, plots will be established for actual field testing to determine productivity. This is a new project.

25. Peat Development Environmental Assessment on Block Island, R.I.

Objective: To conduct an environmental-technological assessment of peat as a potential source of energy on Block Island, R.I., a small island community which, because of its separation from the mainland, has the highest electrical energy costs in the United States. The environmental analysis will include the quantification and qualification of the island's air, water, land, flora, and fauna. Using this information as a baseline control, each technological option for developing the island peat resources will be evaluated

for its potential impacts on the island environment. One of the more crucial areas of environmental investigation will be the socioeconomic aspects of peat development on the island, and what the impacts might be (both good and bad) for each of the technological options of development evaluated. This is a new project.

26. Environmental Impact of Lignite Mining in Western Tennessee

Objective: To investigate the feasibility of mining western Tennessee lignite with respect to ground water, soil resources, and slope stability in the area. The hydrologic system will be investigated to anticipate potential environmental problems that might crop up as a result of future lignite mining in the area. The baseline water resources data will be organized into a computer data retrieval system. From this, predictions can be made, and then, during and after mining, assessments can be made of the impact on water resources in the study area. This is a new project.

27. Environmental Impacts of Borehole Mining of Phosphate Ore

Objective: To determine the environmental, technical, and economic feasibility of mining phosphate ore with the Bureau of Mines borehole mining system. The environmental factors to be considered include subsidence and effects upon ground water. A survey of the land surface shall be made prior to the start of mining operations to establish a baseline for subsequent measurements of subsidence. Premining and postmining samples will also be taken to determine the ground water quality. This is a new project.

28. Assessment of Soil Compaction Problems Resulting From Soil Restoration in Midwestern United States

Objective: To analyze the factors that create differences in compaction characteristics between natural and restored soils over mined areas in the Midwest and to develop strategies to minimize the difference. Information from this study will be useful in developing baseline information to assess potential impacts of practices in mined-land restoration with respect to soils and land use, and is in support of proposed OSM rules governing enhancement and preservation of the environment. This is a new project.

29. Assessment of Water Pollution Problems Associated With Iron Range Mining

Objective: To examine current iron range water problems, identify areas of major environmental concern, and recommend future research. The water requirements, use, and disposal for iron range mining will be surveyed. This is a new project.

# CONTROL TECHNOLOGY

## Subprogram Goals

This subprogram's overall goal is to provide new and improved technology that can be used by the mining and mineral-processing industries for the prevention and/or control of adverse environmental impacts. Specific goals of this subprogram are--

1. To develop mining techniques or processing methods that minimize the adverse environmental effects of mining.

2. To develop economical equipment systems to support the selected techniques.

3. To transfer this technology to the industry through field demonstrations, films, publications, and other appropriate means.

## Reclamation

### In-House Projects

1. Identification of Reclamation Problems in Metal and Nonmetal Mines in Alaska

Objective: To identify reclamation problems in metal and nonmetal mines in Alaska. The problems that need addressing and require research will be identified. This is a new project.

2. Reclamation Equipment Application: Technology

Objective: To investigate, analyze, and monitor current reclamation technology and ongoing research in the surface mine industry. Identify existing problems, anticipate future developments, and formulate a coordinated program of research and development to improve mined-land reclamation. This is an ongoing project.

3. Computer-Supported Analysis of Surface Mining Systems

Objective: To use simulation models to evaluate new mine systems and reclamation equipment concepts proposed, developed, and demonstrated under the Minerals Environmental Technology Program to determine potential for improving reclamation technology of surface mining operations. This is an ongoing project.

4. Reclamation Requirements of Phosphate Industries in the Southeastern and Western States

Objective: To survey reclamation requirements, compile a bibliography of mining and reclamation technology, collect field data on reclamation operations, and provide lists of current research and development needs. Final product will be a publication on reclamation practices in the Southeastern and Western United States. This is an ongoing project.

5. Iron Range Mined-Land Reclamation

Objective: To determine current practices and delineate the mined-land reclamation needs in the Mesabi, Cuyuna, Gogebic, and Marquette iron ranges in northern Minnesota, Wisconsin, and Michigan, and to develop background information for contracts to advance state of the art of cost-effective, land reclamation practices in these districts. This is an ongoing project.

6. Specialized Mined-Land Reclamation Equipment

Objective: To analyze current mined-land reclamation equipment design and practices, and generate improved equipment designs and uses to meet current reclamation requirements; to perform preliminary evaluation of these concepts for advancing the state of the art of mined-land reclamation equipment and utilization practices. Detailed feasibility analysis of the most applicable equipment designs and practices will be performed by follow-on research contracts with the necessary background information for the RFP's prepared in this project. This is an ongoing project.

7. Identification of Revegetation Problems in Arid and/or Semi-Arid Regions

Objective: To evaluate the impact of climate on noncoal mine revegetation efforts and assess possible remedies. This is a new project.

8. Potential Environmental Problems in Surface Mining of Bentonite

Objective: To identify and assess the environmental problems associated with surface mining of bentonite. Methods for dealing with problems will be identified. This is an ongoing project.

9. Environmental Aspects of Uranium Mining in Minnesota

Objective: To define possible environmental problems, develop baseline environmental monitoring programs, and initiate environmental effects research. This project will involve work with the State, landowners, and potential mining companies. This is an ongoing project.

Contract Projects

1. Development of Improved Topsoil Handling Techniques

Objective: Develop new techniques and equipment combinations which more effectively use topsoil for reclamation in accordance with State and Federal regulations. This is an ongoing project by Skelly and Loy.

2. Production, Engineering, Development, and Demonstration of the Draft Power Sensor

Objective: To develop and test an improved version of a draft power sensor to be attached to the dozers used in regrading spoil after mining. Previous research developed and tested a prototype sensor. The results indicated potential regrading cost savings and productivity increases. This project seeks to develop a rugged production version and expand the field testing. This is an ongoing project by Southwest Research Institute.

3. Improved Topsoil Placement Techniques To Reduce Compaction

Objective: To develop and improve the techniques of reclamation and topsoil distribution to avoid tight compaction of soil before seeding operations. This would be accomplished by analyzing current soil distribution methods that use scrapers and dozers. Other areas to consider would be: (1) Selective handling and placement of soil and overburden; (2) ripping (on contour) to breakup compaction; and (3) current bearing pressures used on dozers and scrapers during topsoil placement. This is a new project.

4. Development of Equipment Selection Guidelines for Surface Reclamation Work

Objective: To develop guidelines for evaluating and selecting equipment used in reclaiming surface mined land. This will be accomplished by field-testing equipment, including rubber tire dozers, front-end loaders, and utility draglines, to determine its production and cost rates as well as operator acceptance in reclamation work. The data will be combined with existing data on crawler dozers and angle blades into a handbook. This is a new project.

5. Preparation of a Script for a Technology Transfer Film Depicting the Use of Specialized Recontouring Blades for Surface Coal Mine Reclamation

Objective: To write a script for a technical film on reclamation blades based on the recent demonstration in an east Texas lignite mine in cooperation with Texas Power and Light Co. The film will inform mine operators of the potential of the regrading equipment systems. This is an ongoing project by Tech Films, Inc.

6. Development of Dragline Techniques for Reclaiming Spoil

Objective: To investigate, develop, and demonstrate special dragline reclamation techniques for reclaiming and recontouring spoil in applicable situations, such as (1) filling modified area mine final cuts, (2) contouring head of hollow fill in mountain top removal, (3) relocating the large volumes of spoil atop the highwall when mining of dipping seams is completed, and (4) moving spoil uphill to recontour conventional contour mining operations. This is an ongoing project by Math Tech, Inc.

7. Analysis and Development of Selective Overburden Handling Mining Systems

Objective: To design and develop innovative systems using existing equipment for selectively excavating and placing the overburden in the most optimum sequence to eliminate environmental problems and provide for post-mining use as farmland. Develop functional specifications and concepts for new equipment capable of selectively excavating and depositing overburden and topsoil materials. This is an ongoing project by Marston and Marston, Inc.

8. Demonstration of Land Reclamation Equipment and Transfer to Active Mines

Objective: To introduce and successfully transfer to the surface coal mining industry the technology of specialized reclamation tools developed by the Bureau of Mines. Initially, a 4-month demonstration of selected reclamation techniques was conducted. Three recontouring blades were successfully applied as a reclamation system designed to recontour area mine spoils. A second demonstration will be conducted this year, and dragline systems for recontouring will be field-tested. This is an ongoing project by Russell and Sons.

9. Methods for Surface Mining of Coal Reserves That Have Been Partially Mined by Underground Methods

Objective: To investigate those surface mining methods presently being used on coal reserves that have already been underground-mined, and to recommend other mining methods that would also be appropriate under such conditions. This is a new project.

10. Suitability of Dry Land Sodding as a Reclamation Tool in the Western United States

Objective: To prepare a report that concisely describes the soil, overburden, vegetative, and climatic characteristics of the Northern Great Plains and Rocky Mountain Coal Province, and identify the necessary characteristics of a dry land sodding system that would be feasible in this area. This is an ongoing effort by JoAnn Toore-Hackos and Jane E. Bunin.

11. Reclamation of Tailings Basins Resulting From Copper-Nickel Milling Operations

Objective: To develop methods for reclaiming tailings basins resulting from copper-nickel milling operations, with emphasis on methods of establishing vegetative cover. Selected plantings will be tested on tailings at a selected mine site. This is a new project.

12. Enhancing Short- and Long-Range Availability of Nitrogen and Phosphorus on Topsoil-Deficient Mine Spoil

Objective: To improve the short- and long-range availability of nitrogen and phosphorus in topsoil deficient mine spoils, and to deliver research findings to mine operators, regulatory officials, extension workers, and other interested individuals through demonstration plots and written materials. This is a new project.

13. Open Pit Mine Dump Material Characterization

Objective: To conduct a pilot research study to characterize the physical, hydrologic, electrical, and seismic properties of open pit mine dump materials; to delineate stratification of these materials; and to determine depths and construct profiles of the contact between the dump materials and the original land surface utilizing geophysical techniques. This is a new project.

14. Establishment of Associative Nitrogen Fixing Grasses on Metal Tailings

Objective: To stabilize metal mine tailings with grasses capable of providing their own nitrogen in association with nitrogen fixers inhabiting their roots. This is a new project.

15. Determination of the Optimum Topsoil Depth for Surface-Mined Areas Within the Northern Great Plains Coal Province

Objective: Evaluating varying depths of topsoil on regraded mine spoils with respect to their adequacy for supporting reestablished vegetation. This is the third year of study in an ongoing effort by Colorado School of Mines Research Institute.

16. Development of Methods for Reclaiming Abandoned Tailings Ponds and Dams

Objective: To determine the state of the art and the problems involved in the removal of tailings ponds and dams in carrying out reclamation of abandoned mine sites, and to develop methods for reclaiming abandoned tailings ponds and dams. This is an ongoing effort by Harding-Lawson Associates.

17. Modular Irrigation Equipment for Reclaimed Strip-Mined Lands

Objective: To develop preliminary designs for a modular irrigation system(s) for revegetation of Western surface coal mined land. Each irrigation system will be evaluated according to its technical and economic feasibility. This is an ongoing effort by Sherman & Sullivan.

18. Reclamation Planning for Wooded Draw Areas in the Northern Great Plains

Objective: To perform a baseline environmental review of a wooded draw mining site on the Northern Great Plains. This contract will also include the development of new or modified assessment techniques necessary for an environmental review of a wooded draw area. This is a new project.

19. Utilization of Nickel-Refining Byproducts on Agricultural Lands

Objective: Plant growth and elemental uptake studies will be made for spent laterite and metal ammonium phosphate byproduct additions to soil both in greenhouse and outdoors. Nutrient requirements and vegetative yields will be determined for various application rates. This is an ongoing effort by Oregon State University, Corvallis, Oreg.

20. Development of an Attachment to a Load-Haul-Dump Vehicle for Transplanting Tree Clumps

Objective: To develop and fabricate an attachment for a front-end loader of 7 to 12 cubic yards capacity that will transplant clumps of trees for surface mine reclamation. This load-haul-dump system will be field-tested and evaluated in an operating surface mine with an ongoing reclamation program. This is an ongoing effort by Colorado State University.

21. Breeding of Improved Grasses for Mined-Land Reclamation

Objective: To make available to Bureau of Mines the improved plant stock being obtained by selective breeding at the Agricultural Research Crops Research Laboratory, located in Logan, Utah. Plant stock will be field-tested by the Bureau. This is an ongoing effort by USDA Science and Education Administration--Agricultural Research.

22. Reclamation of Mined Areas To Minimize Adverse Impacts on Fish and Wildlife

Objective: To identify Best Technology Currently Available (as defined by Office of Surface Mining and Enforcement) to minimize adverse surface mine impacts on fish and wildlife and related environmental values. This is an ongoing effort by the Fish and Wildlife Service, U.S. Department of the Interior.

## Water Management

### In-House Projects

1. Electrokinetic Technique for Clearing Abandoned Sediment Ponds

Objective: To demonstrate (through field tests) the feasibility of using direct current to clarify surface water and consolidate coal waste to facilitate reclamation of abandoned sediment ponds. This is an ongoing project.

2. Design of Slime-Sealed Impoundments To Prevent Ground Water Contamination

Objective: To develop a relatively impervious base for tailings ponds to reduce the water loss into the ground water by utilizing natural soils, clays, tailings slimes, additives, and compaction in various combination to attain permeabilities of $1 \times 10^{6}$ to $1 \times 10^{7}$ units. Such a base would replace fabric liners. This is an ongoing project.

3. Waste Water Monitoring Techniques for Uranium Tailings

Objective: To develop and test techniques for measuring and analyzing water balance systems for tailings ponds and methods of detecting and sampling seepage water in partially saturated foundation soils. This is an ongoing project.

4. Citrate Process: Chemistry and Engineering

Objective: To evaluate the effectiveness of changes in the citrate process for scrubbing sulfur dioxide from stack gases. Research will be conducted on the merits of steam-stripping of sulfur dioxide at elevated temperatures and pressure, generation of hydrogen sulfide using solid reductants, the substitution of potassium citrate for sodium citrate, and alternative reactor configurations to avoid sulfur accumulation. Laboratory support for the demonstration plant will also be provided. This is an ongoing project.

5. Cleanup and Recycle Technology for Mine and Mill Waters

Objective: To devise process-water treatments that permit water reuse or safe discharge and recovery of minerals and metals contained in the waters. Work will include the removal of heavy metals from ammoniacal process solutions used in permit fertilizer production; removal of selenium from uranium mine waste water in Ambrosia Lake, N. Mex.; and recovery of molybdenum catalyst preparation waste water. This is an ongoing project.

6. Modification of Mineral-Processing Tailings and Wastes

Objective: To devise in-line process-control technology to reduce the leaching of elements and compounds by rainfall or ground water from mineral-processing wastes. This is an ongoing project.

7. Stabilization of Mining and Mineral-Processing Wastes

Objective: To devise, improve, and field-test methods for stabilizing mining and mineral-processing wastes, and to evaluate effectiveness of these methods in minimizing air and water pollution and other adverse environmental impacts. Established test and demonstration plots will be monitored and evaluated. Grasses will be evaluated for ability to tolerate conditions, the presence of base-metal salts, and to fix nitrogen. The relation of plant growth to microorganism populations in tailings will be evaluated. This is an ongoing project.

8. Water Recovery From Phosphate Clay Slimes

Objective: To field-test the polyethylene oxide rotary screen dewatering technique for treating clay slimes at operating Florida phosphate plants. The quality of the water released will be evaluated and procedures developed for making the water satisfactory for reuse. Laboratory tests of potential new flocculants and flocculant extenders will be carried out. Improved dewatering devices will also be tested. This is an ongoing project.

## Contract Projects

1. Assess the Water Quality Problems Associated With Underground Metal Mines

Objective: To identify watersheds adversely affected by drainage from abandoned and idle metal and nonmetal mines. The magnitude of the problem at each watershed evaluated, pollution sources pinpointed, and corrective measures designed. This is a new project.

2. Analysis of Ground Water Criteria and Recent Restoration Attempts

Objective: To present, compile, and compare the criteria for ground water quality restoration and the effectiveness and costs of the methods employed. To develop empirical expressions for predicting the amount of aquifer flushing required, and to improve predictions for the costs of restoration. This is an ongoing effort by Resource Engineering and Development, Inc.

3. Evaluation of Lixiviation of Mine Wastes

Objective: To determine which types of, and to what extent, mineral wastes contaminate ground water through leaching of acid-forming or toxic-forming materials. This is an ongoing effort by Calspan Corp.

4. Detection of Lixiviant Excursions With Geophysical Resistance Measurements During In Situ Leaching

Objective: To develop, test, and demonstrate a geophysical resistance-measuring system to reliably detect the excursion of a lixiviant (of relatively approximately half that of the ground water it displaces) before lixiviant arrives at the monitor well, to the depth of at least 400 feet. This is an ongoing effort by Westinghouse Electric Co.

5. Inexpensive Acid-Resistant Grout for Applications in Leaching

Objective: To evaluate existing acid-resistant grouts and cements, formulate several lower cost materials, laboratory-test these materials for acid resistance, and recommend the best products for field testing for applications in leaching. This is a new project.

6. Grouting Methods To Prevent Ground Water Contamination From Dump and In Situ Leaching

Objective: To evaluate the technical and economic feasibility of using grout curtains to contain fluid flow in conjunction with dump and in situ leaching operations. This is a new project.

7. Source of Metallic Pollutants in Runoff Water From Copper-Nickel Ore Stockpiles

Objective: To determine the presence of metals in runoff water from copper-nickel ore stockpiles as a function of material composing the stockpiles and bacterial activity. This is a new project.

8. Development of Dewatering Systems for Surface Coal Mines in the Interior Provinces

Objective: Existing dewatering technology was reviewed and evaluated for use in the Interior coal province. Guidelines for design and operation of dewatering systems were developed which will aid operators in selection of dewatering systems. Dewatering (drainage of overburden water) prior to mining will improve pit wall stability and decrease blasting problems. Additional funding is needed to cover cost escalation in the preparation of the final report. This is a continuation of an ongoing effort by Woodward-Clyde Consultants.

9. Pilot-Scale, Onsite Evaluation of Activated Carbon for Rapid Oxidation of Ferrous Iron in Acid Mine Water

Objective: To evaluate the use of activated carbon for the rapid oxidation of ferrous iron in coal mine drainage. A pilot-scale experiment will be based on previous laboratory work done by the Bureau of Mines. Experiments will be conducted at the site of the Warwick No. 2 Mine of Duquesne Light Co., and the results will be reported. This is an ongoing effort by Rhose Island Analytical Laboratories.

10. Feasibility of Water Diversion and Overburden Dewatering

Objective: To conduct a critical analysis of all literature and current engineering practices relating to the diversion of water from coal mine workings. Diversion methods that have proven to be feasible or cost effective or offer a high potential for utilization will be described and critically reviewed for potential users. This is an ongoing effort by Hittman Associates, Inc.

11. Development of a Dewatering System for Controlling Fracture Dominated Inflow for Acid Mine Drainage Abatement

Objective: To design and field-test a pilot-scale fracture dewatering system for acid mine drainage abatement. Site selection and the development of preliminary design will provide the basis for a pilot dewatering demonstration. This is a new project.

12. Minimizing Hydraulic Disturbance Caused by Surface Mining

Objective: To assess impacts of surface metal and nonmetal mining on ground water and place those impacts in context with other types of disturbances to ground water resources; to evaluate the state of the art of science and technology for minimizing the impacts of mining and assess the need for various programs of research and training to assist in coping with problems of surface coal mining and its impact on ground water resources. This is a new project.

13. Natural Restoration From In Situ Uranium Leach Mining

Objective: To determine the ability of the sandstone-aquifer system to naturally restore the ground water after in situ uranium leach mining. This is a new project.

14. Selective Placement of Toxic Overburden Material

Objective: To devise analytical systems for the field determination of the occurrence of toxic overburden materials; to devise, demonstrate, and evaluate systems for segregation and isolation of the elements from the ground water system. This is an ongoing effort by Montana State University.

15. Control of Water Pollution From Surface Mining Operations

Objective: To evaluate the varying types and severity of water problems associated with surface mining and determine the most environmentally acceptable ways to handle these problems. This is an ongoing effort by Wapora, Inc.

16. Seepage Through Partially Saturated Shale Waste

Objective: To develop and demonstrate a finite-element computer code which could be used for unsteady, unsaturated flow of water through spent shale piles. Filtration ponds constructed of spent shale at Anvil Points, Colo., were analyzed and results compared to field measurements. This is an ongoing effort by the University of Idaho.

17. Comprehensive Planning To Optimize Postmining Land Use by Water Harvesting

Objective: To demonstrate the concept of water harvesting as a means of obtaining greater economic return to offset the cost of reclamation. This project includes evaluation of the modeling effort in a previous study in order to determine optimum regrading for a given site. The purpose is to reduce erosion and sedimentation, to achieve the potential for successful revegetation, and to reduce the cost of regrading and reclaiming spoils. The project is in its third year. This is an ongoing effort by the University of Arizona.

18. Investigation of the Mechanics of Mine Acid Formation in Underground Coal Mining Drainage

Objective: To obtain definitive information regarding the mechanics of chemical and biological processes affecting the formation of toxic mine drainage in order that control processes might be devised. This is an ongoing effort by ECO Control, Inc.

19. Study of the Hydrology and Water Quality of Watershed Subjected to Surface Mining

Objective: To determine the effects of surface mining on hydrology and water quality. The study is in its fourth year. Two watersheds have been mined and reclaimed. Premining baseline data have been collected on five small watersheds. A third watershed is expected to be mined this year. Erosion plots will go into operation in the spring of 1980. This is an ongoing effort by Ohio Agricultural R&D Center, and USDA Science and Education Administration--Agricultural Research.

20. Water-Handling Procedures for Reducing Acid Formation in Underground Mines

Objective: To establish sound procedures for water drainage in underground coal mines that would minimize the formation of acid and iron pollutants. This is an ongoing effort by Skelly and Loy.

21. In Situ System for Detection of Toxic Overburden

Objective: To develop a detection system capable of locating in situ zones of toxic materials in overburden of potentially surface-minable coal lands. This is a new project.

22. Application of Resins To Remove Hazardous Material From Abandoned Tailings

Objective: To field-demonstrate Bureau-developed resins that eliminate hazardous material from abandoned tailings. In some cases, these resins may be the only method available. This is a new project.

23. Contamination of Ground and Surface Waters by Uranium Mining and Milling

Objective: To measure rate of pollutant migrations from uranium mining and milling operations, develop improved techniques for describing these migrations and predicting their rates, determine if algae and bacteria can be used to lower pollutant concentrations and hence, reduce water pollution. This is an ongoing effort by the University of Colorado.

24. Predicting Mine Water Inflow and Impact on District Hydrology

Objective: To develop and validate a method(s) for predicting mine water inflow by improving interpretation of flow system parameters, and to develop a method to determine surface and ground water depletion relative to mine water inflow. This is a new project.

25. Assessment of Effects on Ground and Surface Water Around Coal and Mineral Storage Areas

Objective: To survey the extent to which storage piles of coal and minerals release toxic ions or other significant organic pollutants to ground and surface waters. Pollution types and levels will be assessed, and mitigative measures for each mineral commodity will be developed for improved control of runoff. This is an ongoing effort by Hittman Associates, Inc.

26. Tug Valley Flood Study

Objective: To assess the relative effect of land use on the flooding problem of the Big Sandy River Basin in West Virginia, Kentucky, and Virginia, with emphasis on the Tug Fork. The magnitude and timing of peak flow hydrograph changes will be identified for a range of soil covers typically resulting from various land uses present in the Basin and related to downstream flood inundations. Changes in runoff hydrographs are to be by land use or cover types. A secondary objective is to collect selected water-quality data at certain mined areas. This is a new effort by USGS.

27. Interaction of Acid Mine Water and Concentrator Waste

Objective: To determine the solution chemistry involved in improved water treatment resulting from mixing alkaline copper concentrator tailings slurry with process waste water to precipitate soluble metals. This is an ongoing effort by the Montana College of Mineral Sciences and Technology.

28. Effect of Thiobacillus Ferrooxidans on the Weathering of Tailings

Objective: To determine the effect of bacteria on the weathering of chalcopyrite or lead-zinc leach tailings with emphasis on tailings generated by ferric chloride or chlorine-oxygen leaching. This is an ongoing effort by the University of Nevada, Mackay School of Mines, Reno, Nev.

29. Biological Oxidation of Iron (II) by T. ferrooxidans in a Sequencing Batch Reactor

Objective: To study the biochemical oxidation of Fe(II) utilizing *T. ferrooxidans* bacteria absorbed on clay. The process will be studied as a function of temperature, time of reaction, settleability, solution flow rate, iron concentration, aeration rate, and clay concentration. One reactor will be operated continuously to develop a community of organisms. A full-scale reactor system will also be designed. This is a new project.

30. Dewatering Slimes To Eliminate Tailings Ponds

Objective: To evaluate potential techniques to dewater tailings ponds. Techniques will be tested on tailings from various sources. This is a new project.

31. Measurement of Seepage Beneath Tailings Ponds

Objective: Collect data on water seepage through the slime layer of tailings ponds. This is an ongoing effort by Asarco, Inc.

## Alternative Processes

### In-House Projects

1. Control and Recovery of Accessory Minerals From Lead and Zinc Process Wastes

Objective: To develop hydrometallurgical procedures for recovery of accessory and other metal values from wastes generated in the milling and smelting of lead and zinc concentrates. Research will emphasize the recovery of cadmium, zinc, and lead from lead smelter flue dust, cadmium and zinc from electrolytic zinc plant copper cake, and zinc and predonderant metals from electrolytic zinc plant iron cake. This is an ongoing project.

2. Citrate Process: Evaluation and Selection of Materials

Objective: To evaluate and recommend corrosion-resistant construction materials for equipment to be used in the citrate process demonstration plant. This is an ongoing project.

3. Minerals Recovery From Copper-Smelting Slags

Objective: To determine the distribution, with respect to operating conditions, of minor, potentially toxic elements such as arsenic, antimony, bismuth, selenium, and tellurium between matte and slag, and to recommend methods for concentrating these elements in the slag for possible recovery. This is a new project.

4. Treatment for Copper Solvent Extraction Emulsions

Objective: To devise procedures of utilizing magnetic fluids to aid in breaking undesirable emulsions formed in the solvent extraction of copper from aqueous leach liquors. Best procedures for recovering the organic phase and the aqueous phase for recycling will be evaluated. This is a new project.

5. Control of Toxic Elements in Leaching Processes

Objective: To improve copper leaching technology by developing techniques to prevent undesirable elements, such as arsenic and selenium, from becoming mobilized during the hydrometallurgical extraction of copper. This is a new project.

6. Citrate Process: Removing $SO_2$ From Powerplant Stack Gases

Objective: To test and evaluate a prototype plant to demonstrate the Bureau's citrate process for removing sulfur dioxide from the stack gases of powerplants burning high-sulfur coal. The new facility at St. Joe Minerals Corp.'s George F. Weaton Power Station in Monaca, Pa., will be monitored by Radian Corp. under contract to the Bureau. Laboratory backup needed to support the demonstration project will be provided. This is an ongoing project.

## Contract Projects

1. Development of Environmentally Attractive Leachants

Objective: To determine whether sodium carbonate or potassium carbonate, with or without clay-encapsulating additives, can be sibstituted for ammonium carbonate as a leachant without excessive cost or loss of permeability; to determine the optimum strengths of these leachants for extracting uranium from several types of sandstone ores. This is an ongoing effort by the University of Texas.

2. Tests of Environmentally Attractive Leachants

Objective: To field-demonstrate techniques developed under contract project 1, above. This is a new project.

3. Testing and Evaluation of Citrate Process Demonstrations

Objective: To test and evaluate the Bureau's citrate process demonstration plant to obtain information on the economic viability of the citrate process for removing $SO_2$-bearing gas from a coal-fired powerplant. This is an ongoing effort by Radian Corp.

4. Demonstration of the Citrate Process $SO_2$-Removal System

Objective: To design and construct a demonstration plant for the removal of $SO_2$ from stack gases at the 50-megawatt George F. Weaton powerplant at Monaca, Pa. Design capacity is 156,000 scfm of 0.2 vol-pct $SO_2$ yielding 16 tpd sulfur. This is an ongoing effort by St. Joe Minerals Corp.

## Surface Stability

### In-House Projects

1. Analysis of Deformation and Stability of Surface Coal Mine Spoil

Objective: To investigate and describe the response to load of surface coal mine spoil materials, so that accurate predictions can be made of structural support characteristics, settlement, and mass stability for various mining and post-mine configurations and geologic conditions. This is a new project.

2. Evaluating Desliming Techniques

Objective: To examine, test, and assess new techniques for the stabilization of slimes. Information on the various techniques for stabilizing slimes will be collected to form a data base for evaluation of desliming techniques. Information will come from Bureau of Mines and other government projects, industry, and university research. Laboratory tests will be conducted on promising techniques to determine their potential and the additional R&D needed to produce a viable slime stabilization method. This is a new project.

3. Investigation and Development of Improved Methods for Stabilizing Slopes and Controlling Sediment From Mined Areas

Objective: To investigate the engineering and hydrologic principles related to soil stability and erodability, and to demonstrate the application of these principles in mined-land reclamation. This is a new project.

Contract Projects

1. Stability of Surface Mine Spoils at Central U.S. Coal Mines

Objective: To relate the various practices of spoil emplacement in the study areas to the specific degree of stability or instability associated with each area. The relationship between ground water and spoil stability characteristics will be determined, as well as the techniques of spoil emplacement necessary to assure optimum stability. This is an ongoing effort by Shannon and Wilson, Inc.

2. Environmental Effects of Slaking of Surface Mine Spoils

Objective: To determine effects on surface stability and erosion caused by deterioration of overburden materials exposed to weathering processes and water. A review of weathering research and testing precedes a field examination of four sites in selected mining districts. This is an ongoing effort by D'Appolonia.

3. Investigation of the Subsidence and Surface Collapse Features in Reclaimed Fort Union Surface Coal Mine Spoils

Objective: To determine the stability of regraded surface mine spoils and to examine the resulting effect on ground water quality. Results will be used to help determine postmine land use of affected areas. This is an ongying effort by North Dakota Geological Survey.

4. A Study of Surface Coal Mine Slope Stability

Objective: To quantitatively assess the slope instability problems associated with coal surface mining in the eastern coal province. Spoil placement techniques that provide slope stability will be recommended. This is an ongoing effort by Law Engineering Testing Co.

5. Effects of Test Procedures on Analysis of Gradation and Strength of Surface Coal Mine Spoil Materials

Objective: To assess and compare the requirements and results of using recompacted versus "undisturbed" specimens in triaxial shear tests on surface coal mine spoil. Work will include determining the relative influence of initial gradation and degradation during shear of particles making up triaxial samples. This is a new project.

6. Stability Analysis of Valley Fill Construction

Objective: To determine the effects of variations in geology, fill type, and construction method on density, the fill slope stability, and internal drainage. Mass settlements and ground water transmission for alternative design and construction practices are to be characterized. These designs will be evaluated with respect to economy of construction, site reclamation, and long-term site utilization. This is a new project.

## Land Use Alternatives

### In-House Projects

1. Compilation and Analysis of Environmental Data From EIS's and Mine Permits

Objective: To provide the Bureau information and assistance in research planning for the Minerals Environmental Technology program primarily by compiling and analyzing information from sources such as EIS's and mine permits. Work includes determining methods of predicting, evaluating, and abating the impact of the various factors on the natural and human environment from ongoing and planned mining; and estimating the environmental impact of mining by 1985. This is a new project.

### Contract Projects

1. Earthworks: Land Reclamation as Sculpture

Objective: To establish and document a format for public and private involvement and responsibility in the planning of innovative reclamation uses for abandoned gravel pits, landfill sites, and rock quarries. This is an ongoing effort by the King County (Washington) Arts Commission.

2. A Computer Simulation Model for Surface Mine Reclamation Planning

Objective: To expand the capabilities of the existing open pit material-handling simulator to provide the logic necessary to simulate techniques of spoil leveling, highwall reduction, topsoil handling, and rock removal. This is an ongoing effort by Pennsylvania State University.

3. Technical Advice and Support in the Preparation of a Field Guide for Reclamation Planning and Pollution Control for Small Sand and Gravel Operations

Objective: To provide technical advice and support in the preparation of a field guide that will provide the small operator with information on reclamation and pollution control requirements and procedures. This is an ongoing effort by Interstate Mining Compact Commission.

4. Development of a Field Guide for Reclamation Planning and Pollution Control on Small Sand and Gravel Mining Operations

Objective: To provide the small operator with information on reclamation and pollution control requirements and procedures. The field guide will serve as a handbook on solutions to environmental problems. This is an ongoing effort by Hittman Associates, Inc.

5. Abandoned Mine Reclamation: "A Case Study at Live Oak, Florida"

Objective: To demonstrate the development potential of abandoned mine lands. Alternative land use plans are to be developed in order to evaluate the development potential of a 3,000-acre, abandoned gravel pit near Tallahassee, Fla. Five reclamation plans are to be detailed in the context of the needs of potential industrial-commercial users. This is an ongoing effort by the Center for Resource Development.

6. Land Use Planning Study for the Crow Indian Tribe in Southeastern Montana

Objective: To develop a prototype evaluation system for the siting of coal surface mines and demonstrate this system on the coal reserve area of the Crow Indian Reservation in Southeastern Montana. This is an ongoing effort by Harvard University, Department of Landscape Architecture.

7. A Systems Approach to Reclamation of Strip-Mined Areas in North Dakota

Objective: To determine the interrelationships of various aspects of reclamation and select the most promising processes to improve reclamation in North Dakota lignite mining areas. This is the fifth year of the study in an ongoing effort by the University of North Dakota.

## Waste Management

### In-House Projects

1. Waste Disposal Planning

Objective: To plan research and avoid duplication of efforts, maximize usage of other project results, prevent technology gaps, and insure continuity of effort in waste disposal. This is an ongoing project.

2. Laboratory Analysis of Settling Rates and Development of Simulated Waste Materials

Objective: To determine the settling rates of manganese nodule wastes and related physical properties by laboratory experiments. A material simulating the properties of nodule waste will be developed for subsequent waste disposal research projects. This is an ongoing project.

3. Evaluate and Monitor Flood Plain Disposal

Objective: To evaluate disposal techniques from information taken directly from Field Test for Environmental Disposal of Mill Tailings in Surface Backfill (contract No. JO188146) and other field-testing done under Bureau contract. This is a new project.

4. Improved Hydraulic Method for Coal Waste Disposal

Objective: To size the coarse fraction of coal waste to a preferred particle size distribution and blend it with the sludge to obtain a stable waste material. The project will provide data to evaluate the transportability and the depositional properties of the refuse blends. This is a new project.

5. Controlled Burnout of Abandoned Coal Fires

Objective: To demonstrate the concept of controlled burnout of fires in abandoned coal mines and waste piles. This is a new project.

6. Environmental Damage Assessment From In Situ Retorting of Oil Shale

Objective: To develop and test acoustic instrumentation and techniques to assess blast damage to pillars and other structures; to characterize rubblization in the retorts of the modified in situ oil shale extraction process; and to evaluate potential environmental hazards resulting from in situ recovery operations. This is an ongoing project.

7. Assessment of the Potential Environmental Impacts and Mitigative Measures Identified by the State of Minnesota Regional Copper-Nickel Study

Objective: To evaluate the potential environmental impacts, as identified by the Minnesota Regional Copper-Nickel Study, that may result from the development of a copper-nickel industry in the State. Mitigative measures necessary to eliminate the potential environmental impacts are to be defined. The applicability of the Minnesota Study to the potential zinc-copper industry in northern Wisconsin will be assessed. This is an ongoing project.

Contract Projects

1. Technical and Economic Evaluation of Underground Disposal of Coal Mine Wastes

Objective: To determine the range of geologic and mining conditions under which underground placement may constitute an economically viable solution for coal mine waste disposal. This is an ongoing effort by HRB Singer, Inc.

2. Field Test for Environmental Disposal of Mill Tailings in Surface Backfill

Objective: To determine if tailings can create land suitable for a wide range of uses, including industrial and residential, by placing the tailings in a controlled environment or river flood plain areas. Determine if such land modifications will result in water pollution as a result of physical or chemical processes. The study will determine if such placement of mine tailings is an economically and environmentally sound alternative for future mining within the Coeur d'Alene Mining District, Idaho. An improved field disposal site will be built using tailings as backfill on the valley floor in an environmentally acceptable manner. This is an ongoing effort by Greater Shoshone County.

3. Stability Analysis for Controlled-Climate Experiments for Disposal of Nodule-Processing Wastes

Objective: To determine the long-term stability of different forms (that is, during various stages of natural and artificial drying) of manganese-nodule-processing wastes under various natural climate moisture conditions. This is a new project.

4. Design and Demonstration of Underground Disposal for Coal Mine Wastes

Objective: To develop and demonstrate techniques for underground disposal of coal mine waste into active underground mines. This is a new project.

5. Design for an Underground Disposal System for Active Uranium Mines

Objective: To develop conceptual designs for backfilling underground uranium mines in the United States, based on mining safety and environmental constraints. This is a new project.

6. Improved Underground Backfilling

Objective: To study the existing constraints, both technical and economic, on the disposal of coal wastes in underground coal mines, and determine a viable filling system(s) utilizing coal-processing wastes. This is a new project.

7. Conceptual Designs of Retaining Structures for Open Pit Backfilling

Objective: To survey typical retaining structures and identify potential for open pit backfilling applications; and to develop conceptual designs for specific mine applications and prepare cost estimates. This is a new project.

8. Field-Testing of Open Pit Backfilling Designs Using Retaining Structures

Objective: To determine by field-testing the technical feasibility and environmental impact of backfilling open pits with the use of retaining structures. This is a new project.

9. Disposal of Solid Wastes From In Situ Uranium Leach Mining

Objective: To determine the feasibility and comparative costs for disposal or storage of solid wastes (obtained from uranium in situ leach mining) in salt domes. This is a new project.

10. Remining as a Potential Tool To Accomplish Reclamation of Abandoned Tailings Ponds

Objective: To develop methods for remining of mine and mill tailings pond waste and to establish material content levels that would make recovery operations economically feasible. This is a new project.

11. Development of Systems for Leveling and Contouring Abandoned Spoil and Waste Banks

Objective: To investigate and evaluate the economic and engineering feasibility of innovative systems for leveling and contouring abandoned spoil banks. Equipment to be used includes wheel excavators or reclaimers, shiftable conveyers, crawler-mounted stackers, and others. This is an ongoing effort by Golder Associates, Inc.

12. Computer Analysis, Physical Properties and Data on Spent Shale

Objective: To complete, with supplemental funding, physical property tests for factors such as strength, permeability, settlement, and composition necessary to design oil shale waste disposal systems that are structurally and environmentally safe. Also to be completed is the literature survey of all available data on physical properties of raw and spent shale from the Green River formation. This is an ongoing effort by the Department of the Army.

13. Investigation of the Flow Characteristics of Mine Tailings

Objective: To develop a method to determine the flow characteristics of liquefied mine tailings and, when a mass of mine tailings flows and liquefies, the probable extent of travel before the mass comes to rest. This is an ongoing effort by the University of California.

14. A Program for Developing a Slurry Grout To Minimize Post In Situ Retorting Environmental Disturbances

Objective: To develop an underground slurry filling system that will minimize surface and underground environmental disturbance. This is an ongoing effort by Rio Blanco Oil Shale Co.

15. Natural Cementation of Retorted Oil Shale

Objective: Additional funding to complete project. This is a continuation of an ongoing effort by CSM Research Institute.

16. Planning, Construction, and Monitoring a Canyon-Fill Retorted Shale Research Disposal Site

Objective: To plan, construct, and monitor an oil shale waste disposal pile containing about 200,000 tons of retorted shale from the Parahoe retort. This is a new project.

## Subsidence

### In-House Projects

1. Instrumentation for Surveying Cavities Created by Borehole Mining

Objective: To develop and test a second-generation instrument package for surveying cavities created borehole mining, and to survey the cavities excavated with the tool and assess the potential for environmental problems. This is an ongoing project.

2. Development of Subsidence Prediction Techniques for Room-And-Pillar Workings

Objective: To develop empirical techniques for the prediction of surface ground movements over room-and-pillar mines. Such techniques are to be presented in a form that can be used by both applicants for permits for underground mining and regulatory authorities, relative to PL95-87. This is a new project.

3. Subsidence-Related Geophysical Parameters

Objective: To establish the changes in physical properties of overlying rock subsequent to mining for the purpose of characterizing the subsidence process. This is an ongoing project.

4. The Effects of Geologic Variation on Coal Mine Subsidence

Objective: To determine geologic and hydrogeologic variables influencing the development of the subsidence profile. The importance of geologic and hydrogeologic variables in relation to mine design will be characterized. The project will also define and develop engineering geologic data useful for subsidence prediction. This is an ongoing project.

5. Subsidence Effects on Structures From Ground Surface Conditions

Objective: To continue collecting subsidence data and monitoring subsidence movement and structural damage, and to complete the analysis of data relating structural damage, ground conditions, and subsidence to mining parameters in the Danville-Hegeler (Ill.) coal mining district. The study will obtain fill-in data and conduct analyses that complement or supplement ongoing contract work. Activities will be coordinated with the "Acoustic-Electromagnetic Properties of Coal Measure Rocks" project to obtain rock core and geotechnical data of mutual benefit to both projects. This is an ongoing project.

6. Characterization of Subsidence Over Longwall Panels

Objective: To improve for coal operators in the Western United States the capability to predict the magnitude, rate, timing, areal extent, and other characteristics of surface subsidence resulting from longwall mining under the thick cover and rugged terrain common in the West. Monitoring subsidence at several active mines will provide new data and an opportunity to correlate it with existing subsidence information and available prediction techniques. The results can then be analyzed with respect to the physical conditions of Western U.S. mines and monitoring techniques likely to be utilized by mine operators. This is a new project.

7. Subsidence Prediction and Analysis Using the Finite-Element Method

Objective: To develop analytical techniques to enable prediction of subsidence and analysis for ground movement due to underground mining activities using the finite-element method of stress analysis. This is an ongoing project.

8. Analysis of Subsidence Data From Solution Mining

Objective: To measure subsidence over an actively subsiding solution mine cavity. This data is to be correlated with mine geologic features, and the feasibility of predicting surface collapse based on this type of information will be determined. This is an ongoing project.

Contract Projects

1. Measurement of Surface Subsidence Over Pillar Extraction Panels

Objective: To determine the degree and character of subsidence that results from pillar-extraction mining and to project the results to roughly assess the effects of this mining method upon surface environment and topography. This is a new project.

2. Environmental Ramifications of Subsidence Resulting From In Situ Retorting of Oil Shale

Objective: To determine the degree to which subsidence occurs during in situ mining of oil shale, and to specify parameters controlling subsidence. The environmental ramifications and effectiveness of proposed control techniques will be determined. This is a new project.

3. Development of Conceptual Model for Room-and-Pillar Subsidence

Objective: To develop a conceptual model(s) that describes the phenomenon of surface subsidence over room-and-pillar workings. This is a new project.

4. Premining and Postmining Surveys and Subsidence Damage to Structures

Objective: To identify the important parameters to be measured and recommend the instrumentation that should be used and the methods for reducing and presenting data in a standardized way in premining and postmining surveys on structures susceptible to subsidence damage. This is a new project.

5. Laboratory Experiments To Determine the Roof Behavior of Auger Mining With Aerostatic Support

Objective: To test a 1:20 scale model of auger mining with aerostatic support to determine the mechanism of roof behavior and the relationship between aerostatic support, overburden pressure, hole size and spacing, and physical properties of coal and rock. This is an ongoing effort by Engineers International, Inc.

6. Instrumentation for Remotely Detecting the Placement of Injected Backfill Material

Objective: To survey feasible methods for monitoring backfill placement in blind stowing operations, and to recommend most feasible method for design, development, and demonstration. This is an ongoing effort by Earthtech Research Corp.

7. Prediction of Ground Movement by Computer Simulation

Objective: To develop computer software and/or hardware with graphics-display output for predicting subsidence resulting from mining activities. This is an ongoing effort by Pennsylvania State University.

8. Influence of Rock Mass Discontinuities on Coal Mine Subsidence

Objective: To determine the effects of structural discontinuities on the subsidence process. This is a new project.

9. Continuous Dry-Hole Acoustic Logging System

Objective: To develop and deliver to the Government an acoustic velocity probe for continuously logging boreholes for compressional and shear-wave velocity determination. This is a new project.

10. Effects of Coal Mine Subsidence on Ground Water Aquifers in Northern Appalachia

Objective: To assess the effects of coal mine subsidence on surface and ground water resources in Appalachia, to relate various mining methods to depletion of water supplies, and to establish criteria for locating urban and rural water supplies so as to minimize dewatering and degradation of water quality by coal mining. This is an ongoing effort by Science Management Engineering.

11. Survey of Ground Surface Conditions Affecting Structural Response to Subsidence

Objective: To survey and evaluate the influence of ground surface conditions on subsidence damage in the interior or eastern coal provinces of the United States. This is a continuation of an ongoing effort by GAI Consultants, Inc.

12. Effects on Hydrology of Subsidence From Thick Seam Coal Mining

Objective: To identify coal seams greater than 15 feet thick in the Western United States that require underground mining and underlie ground and surface water sources, obtain case histories pertinent to the Western States of subsidence from thick seam mining, and apply the foreign case history information to estimate hydrologic impacts from thick seam mining in the West. This is an ongoing effort by Hittman Associates, Inc.

## Noise, Vibration, and Fugitive Dust

### In-House Projects

1. Electromagnetic Drying of Fine Coal for Minimizing Environmental Degradation by Airborne Dust

Objective: To demonstrate a new, more efficient method of drying fine coal that will minimize airborne dust. This project will use microwave energy in the frequency range of 1 to 3 GHz to dry fine coal for selected sizes less than the plus 1/4-inch fraction. This is an ongoing project.

2. Control of Blasting Dust

Objective: To analyze problems associated with fugitive dust from blasting, determine the need for improved control technology, and prepare recommendations for research and development. This is a new project.

3. Analysis and Technical Clarification of ISO and ANSI Standards on Ground Vibrations and Airblast

Objective: To analyze proposed ISO and ANSI standards and provide technical support on criteria and measurement methods for airblast and ground vibrations. This is a new project.

4. Blast Design To Minimize Airblast and Ground Vibration

Objective: To develop design criteria based on current technology to minimize airblast and ground vibrations and still permit cost-effective blasting at surface mines. This is an ongoing project.

5. Application of Abatement Techniques to Mine Environmental Noise Problems

Objective: To determine and promote the application of noise abatement techniques to the solution of mine environmental noise problems. This will constitute the core project for the environmental noise program designed to correlate and integrate contract research and demonstrate the techniques to the mining industry. This is an ongoing project.

6. Fatigue and Structural Damage of Residential Structures From Repeated Mine Blasting

Objective: To determine criteria for fatigue and structural damage in residential buildings due to ground vibrations from repeated blasting in surface coal mines. The study will include monitoring and analyzing damage to the test structure during low level vibrations and initial aging, settlement, and weather effects. This is an ongoing project.

7. Control of Fugitive Dust

Objective: To analyze, through laboratory and field investigation, various approaches to dust suppression systems to determine important design parameters and establish initial feasibility of alternate systems such as on-haul-truck dry-dust collectors, on-haul-truck waterspray systems to minimize the use of water, and tire tread design to minimize dust dispersion. This is an ongoing project.

8. Control of Blast Noise and Vibration From Contour Mining of Coal in Appalachia

Objective: To determine airblast, ground vibration, and structural damage produced by blasting in contour strip coal mines. Design recommendations for blasting that will minimize these adverse environmental effects are to be developed. This is an ongoing project.

9. Fugitive Dust From Active Mining Operations

Objective: To conduct field surveys of fugitive dust sources at three surface mining sites, including processing mills. Particle size distributions and chemical nature will be characterized. This is an ongoing project.

Contract Projects

1. Environmental Problems With Chemical Dust Suppressants

Objective: To identify potential health risks associated with the use of chemical dust suppressants by the mining industry. The project will determine if adverse environmental effects are associated with the use of these compounds, and recommend for further study those areas where insufficient data exist to make these determinations. This is a new project.

2. Cover Materials and Economics To Control Dust and Erosion

Objective: To evaluate potential materials to control environmental problems resulting from surface degradation of mine waste areas. The project will determine the cost/benefits of obtaining and using the materials to cover the waste areas and examine the effectiveness of potentially favorable alternatives. This is a new project.

3. Control of Fugitive Dust Associated With Reclamation Activities at Surface Coal Mines

Objective: To investigate and analyze the problem of fugitive dust generation associated with the required reclamation activities at surface coal mines; identify current problems; and make recommendations for control measures and future research efforts to solve fugitive dust problems, thereby facilitating compliance with air-quality regulations. This is a new project.

4. Fugitive Dust Study of an Open Pit Coal Mine With the University of Minnesota Mobile Laboratory

Objective: To obtain emission data from open pit mines, develop methodology for determination of fugitive emissions, and test new methods for identifying and quantifying fugitive dust. This is an ongoing effort by the University of Minnesota.

5. Human Response to Blast Noise and Ground and Structure Vibrations

Objective: To determine the subjective response of humans to blasting by correlating human response with the amplitude, frequency, duration, and damping characteristics of the air, ground, and structure vibrations. This is a new project.

6. Technology for Noise Control in Surface Mines

Objective: To identify the environmental noise problems associated with mining operations, develop techniques for monitoring such noise, and identify and recommend technology for abatement of noise problems. This is a new project.

## Mine Closure

### In-House Projects

1. Mine Sealing Demonstration

Objective: To examine past mine sealing programs and techniques and develop and demonstrate new mine sealing methods. This is a new project.

## Contract Projects

1. Design and Develop Seals and Barricades for Closing Hazardous Surface Openings to Abandoned Underground Mines: Western Colorado

Objective: To design and develop low-cost, long-life seals and barricades for closing hazardous surface openings to abandoned underground mines on Federal public lands in western Colorado. This is an ongoing effort by Skelly and Loy.

2. Design and Develop Seals and Barricades for Closing Hazardous Surface Openings to Abandoned Underground Mines: Nevada

Objective: To design and develop low-cost, long-life seals and barricades for closing hazardous surface openings to abandoned underground mines on Federal public lands in Nevada. This is an ongoing effort by International Mining Consultants.

3. Design and Develop Seals and Barricades for Closing Hazardous Surface Openings to Underground Mines: New Mexico

Objective: To examine a representative sample of surface openings to abandoned and inactive underground metal, nonmetal, and coal mines in New Mexico; identify those openings that are a public hazard; and analyze laws and regulations, jurisdictional problems, and enforcement problems pertaining to such hazard elimination. This is a new project.

4. Technical Evaluation of Mine Closure Methods in Copper County, Upper Michigan

Objective: To evaluate the effectiveness of the mine sealing methods that have been used in the Copper County of Upper Michigan. This is a new project.

5. A Case Study of the Sherwood Mine Closure

Objective: To conduct a case study of the Sherwood mine closure to determine the nature and extent of the changes in and above the mine and the return of the depressed water table to its premining or prepumping state. This is a continuation of an ongoing effort by Michigan Technology University.

6. System Design for Controlled Burnout of Waste Bank Fires

Objective: To develop a site-specific design for a burnout facility at the Moss No. 1 preparation plant location of Clinchfield Coal Co. This is a new project.

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